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Hydropower and its distinguished role in the future energy mix

How to solve the energy transition problem?

The "Paris Agreement under the United Nations Framework Convention on Climate Change" clearly stated that global warming must be kept within a maximum of 1.5 °C if one wants to reduce the risk of a global climate collapse. To achieve this goal, steering energy production toward clean, renewable technologies is necessary.

Hence, there is a need for transition from fossil-fuel dominated energy systems to low-carbon alternatives. As of 2018, renewable energy targets had been adopted in 169 countries at the national or state/province level. Sub-national governments are often the first movers in establishing innovative and ambitious mechanisms, even some targeting 100 % renewable energy.[1] However, after a three-year plateau from 2014 to 2016, energy-related carbon dioxide emissions are rising again, reaching unprecedented levels in 2018.[2]

Hydropower is one of the solutions: It is the largest source of renewable electricity generation in the world representing over 16 % of global electricity production – more than all other renewables combined.[3] It should therefore play an an increasingly important role in the energy transition, as it is a proven, mature, predictable and price-competitive technology. Hydropower combines an unrivaled degree of efficiency with an extremely long, reliable plant service life and low CO_2 emissions.

Benefits of hydropower are manifold:

- **Highly predictable and reliable energy source**
- **Flood protection and navigation**
  Through multi-purpose reservoirs with ship locks and water resources management in general
- **Water supply and food security**
  Through a reliable source of water for irrigation
- **Economic growth**
  Through trade, transport and tourism
- **Employment and education**
- **Economic production of "green" hydrogen**
- **Storage capabilities**
  Flexible energy generation and smooth integration of other fluctuating, renewable sources like wind or solar with pumped storage plants; the most proven and reliable form of large-scale electricity storage, providing 96% of the world's storage to date [4]

Energy Payback Ratio & Energy Return On Investment

The "Energy Payback Ratio" (EPR) or "Energy Return on Investment" (EROI) are among the most commonly used energy indicators and defined as the ratio of total energy produced during a system's normal lifespan divided by the energy required to build, maintain and fuel it.

EPR, therefore, is a lifecycle perspective with a high EPR indicating a highly energy-efficient system. Hydropower has the highest EPR of all electricity generation technologies, with up to 267 for run-of-river plants and 205 for storage plants – compared to ratios between 3 and 11 for fossil fuels, 39 for large wind turbines, and 16 for nuclear power.[5]

1 IRENA. Renewables Global Status Report, 2019
2 IEA. Global Energy and CO_2 Status Report, 2019
3 IHA. Activity and Strategy Report, 2019
4 EIA. International Energy Statistics, 2017
5 IPCC. Renewable energy sources and climate change mitigation special report of the intergovernmental panel on climate change, 2012

Recent examples of sustainable hydropower development initiatives

Australia

Australia faces challenges with electrical grid stability. While the largest part of the country's current electricity supply comes from coal, its coal-fired power stations are aging, with many set for retirement. Renewable energy sources, such as wind, solar and hydropower, currently represent 17 % of Australia's total electricity generation. Motivated by its renewable targets, which it is set to reach ahead of schedule, Australia has fixed its focus on renewable energies and, in particular, on technologies that can help restore balance. Pumped storage projects – including two large-scale undertakings, Snowy 2.0 (in New South Wales) and the "Battery of the Nation" initiative (in Tasmania), and various IPP projects including Kidston (in Queensland), Goat Hill (in South Australia), Shoalhaven (in New South Wales) and others – have made it to the forefront of the political and national consciousness. The Federal Government and Commonwealth authorities, among others, are supporting various initiatives.

The Snowy Mountains Hydro-Electric Scheme is fully backed by the Federal Government, while Hydro Tasmania, with the support of the Australian Renewable Energy Agency (ARENA), has been developing a blueprint for the role that Tasmania can play in Australia's electricity market. One option is the expansion of existing hydroelectric assets and the construction of 2 500 MW of new pumped hydro to turn the state into the "Battery of the Nation." Earlier this year, the government of South Australia also committed to grant funding for four new pumped hydro projects. "With 50 percent of total energy generation in South Australia coming from variable renewable energy in 2018 and an expectation that this will increase […], there is an increasing requirement for energy storage to firm and balance the system in that state," said ARENA Chief Executive Officer Darren Miller. "As part of this, pumped hydro has an important role to play in Australia's energy transition."

China

China leads the ranking of countries in terms of installed hydropower capacity. At the same time – as in many preceding years – it also led in commissioning of new hydropower capacity, representing more than 35 % of new installations in 2018.[6] Pumped storage continues to be a priority in China's energy transition. The 1 200 MW Shenzhen station was commissioned last year and is the country's first large-scale pumped storage built in a city, in addition the 600 MW Qiongzhong station entered into operation as well. China promotes green finance for its massive clean energy investment needs. Internationally aligned green bond issuance reached USD 31.2 billion in 2018, making it the world's second largest green bond market.[7]


Budarhals, Iceland

Costa Rica

Reventazón is the largest hydropower project in Central America with 305.5 megawatts of installed capacity. The plant is located on the Reventazón River, 50 km upstream of the Caribbean Sea. Since it came into operation, the project has led Costa Rica to achieve a target of generating 100 % of its electricity from renewable energy sources. The project was awarded the 2019 Blue Planet Prize of the International Hydropower Association (IHA), recognizing excellence in sustainable hydropower development. It was constructed from 2010 to 2016 and financed from a range of national and international organizations, including the Inter-American Development Bank and the International Finance Corporation of the World Bank Group.

Iceland

A prior award winner of the IHA Blue Planet Prize is Iceland's Blanda hydropower project, which has achieved an outstanding score in its application of the Hydropower Sustainability Assessment Protocol. Regarding its annual investments in net capacity additions, Iceland ranked fourth in 2018.[8] The country increased its generating capacity, for example, with the commissioning of the 100 MW Búrfell II hydropower plant.

This new power station was built adjacent to a facility originally constructed in 1969 to utilize surplus flow and increase efficiency during peak load periods.[9] Operator of the plants is the National Power Company of Iceland, Landsvirkjun, the largest operator in the country. The company also invests in digital hydropower solutions for their plants, based on machine learning, artificial intelligence and other future-oriented technologies. At their Budarhals facility, digital monitoring technology for predictive maintenance has been installed to increase reliability and optimize operation, hence increase profitability of the plant.

6 IRENA. Renewables Global Status Report, 2019

7 IHA. Hydropower Status Report, 2019

8 IRENA. Renewables Global Status Report, 2019

9 National Power Company of Iceland (Landsvirkjun), "Hornsteinn lagður að Búrfellsstöð II og stöðin gangsett", 28 June 2018

Although hydropower development might seem complex at first glance, the following three recommendations help support hydropower's potential to deliver on climate agreements in the short term

1. Support the expansion of pumped storage capabilities to harness the full potential of already existing renewable energy sources, like solar or wind, and further develop hybrid power plant models that reliably integrate hydropower with other renewable energy sources.

2. Support opportunities to modernize or upgrade existing plants at an early stage to harness their maximum performance and capacity. Bring the existing fleets to highest technological standards by investing in automation and digi talization, ensuring optimal operation, highest efficiency and avoid potential outages.

3. Support the setup of small hydropower facilities showing low infrastructural impact and low investment costs and thereby replace fossil fired energy generation. The majority of currently unused weirs and dams worldwide are ideally suited for small hydropower solutions.

Being the dispatchable renewable energy source that provides flexibility and stability to the grid, hydropower enables the integration of wind and solar and is therefore essential in order to comply with the global and local CO_2 reduction targets stipulated by governments. Furthermore, classical hydropower in terms of run-of-river plants can also serve as an enabler for the expansion of green hydrogen production by providing more than 6 000 of full load operation hours per year at low costs. The first two demonstration plants for Power-to-Gas in combination with hydropower are in trial operation or under construction at the Rhine River.

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